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Post-Earthquake Fires and Firefighting Activities in The Early Stage in The 1995 Great Hanshin Earthquake

Ai SEKIZAWA

Fire Research Institute
Fire Defense Agency
3-14-1, Nakahara, Mitaka, Tokyo 181

ABSTRACT

A number of concurrent post-earthquake fires occurred in the Hanshin Earthquake. In terms of fire incidence in the regions heavily struck by the earthquake, fires occurred almost uniformly in proportion to the degree of structural damage even other than Nagata-ward in Kobe City where large fires were concentrated. This fact indicates that most of the post-earthquake fires were suppressed in their early stage by fire brigades. The reason for concentration of large fires around Nagata-ward is not only high incidence of fires, but also higher risks of fire spread attributed to city configuration, i.e. ratio of wooden structures, building coverage in the area, and the width of streets, etc. in those regions. In addition, the performance of firefighting activities in the early stage is another key factor to the difference of fire damage by region.

The pattern of ignitions in time order and causes of post-earthquake fires are very similar to those observed in the Northridge Earthquake. These similarities in fire ignitions on both the two earthquakes should be remarked and studied further.

Keywords : *post-earthquake fire, conflagration, city configuration, firefighting activity.*

1. INTRODUCTION

Several crucial lessons were learned from the Northridge Earthquake in Los Angeles in 1994. One year later, the Great Hanshin Earthquake (officially referred to as "the Off-South Hyogo Prefecture Earthquake" by the Japan Meteorological Agency : JMA) happened revealing them to us again on January 17, 1995. It can be said the worst scenario expected to which we did not have enough time to apply the lessons from the Northridge Earthquake to mitigate potential risk in Japan.

Even though the degrees of damage were different, these two earthquakes under the large modern cities have quite a few similarities in terms of structural damages, disruption of lifelines, pattern of fire outbreaks, some barriers to firefighting activities such as damaged fire hydrants, and so on. However, it is also important to point out a significant difference in the damages of the two earthquakes, that is, occurrence of conflagrations in city areas. In the Northridge Earthquake, no conflagration took place except in special occasions like mobile home parks. On the other hand, there were such fires found in Kobe. For this difference in risks of fire spread, the conditions in the city areas, such as building coverage and width of streets, are considered as ones of the most significant reasons. Because, if a number of fires occur simultaneously beyond the firefighting capability to control in zones having high dense wooden structures, fires would inevitably spread.

The Hanshin Earthquake left us a significant task: how to improve means of fire spread prevention in city areas with zones having very packed wooden structures in Japan. In this paper, the post-earthquake fires and fire stop factors in the Hanshin Earthquake are discussed first, and then the outline of firefighting activities in the early stage is discussed.

2. POST-EARTHQUAKE FIRES

2.1 Post-Earthquake Fires in Time Order

Table 1 and Table 2 show the number of fires in time order following the Hanshin Earthquake by city in suffered regions. As seen in Table 1 which shows the number of fires following the earthquake in Kobe City, 109 fires started on the day of the earthquake, and in the following two days, 14 and 15 fires started. The number of the fires gradually decreased, and during 10 days after the quake, 175 fires occurred. However, all the twelve large fires, more than 10,000m² in burned area, occurred on the day of the earthquake, January 17. Also, 60 fires started shortly after the earthquake, thus, the situation can be called "a number of concurrent fires just after an earthquake".

Figure 1¹⁾ provides the data on the number of fires by hours in Kobe City on January 17. The time period "5" on the horizontal line in the figure stands for 14 minutes after 5:46 a.m. when the earthquake struck.

As it is clear from Figure 1, about half of the fires on 17th occurred in 14 minutes just after the main shock. On the other hand, during the day of 17th, about the other half occurred after 6:00 a.m. and some started one by one hours later after the earthquake. Actually, this pattern of occurrence of fires is very similar to the one observed in the Northridge Earthquake.

Figure 2²⁾ shows fires by hours on the day of the Northridge Earthquake in the jurisdiction of the Los Angeles City Fire Department. The profile of the fire occurrence in time order is very similar to that of Kobe City. For this pattern of fire ignitions, the Los Angeles City Fire Department explains as follows. The first wave was formed by a number of fires starting simultaneously just after the main shock. These fires were mainly caused by gas leakage. Also, the second wave was formed by sporadic fires which were mostly electrical fires derived from the recovery of the electricity supply in collapsed structures. The same situation of fire ignitions were observed again in the Hanshin Earthquake. The similarities in the patterns and causes of fire ignitions on both the two earthquakes should be remarked.

2.2 Regional Distribution of Fires

Figure 3³⁾ shows the regional distribution of fires from January 17 to January 19. In terms of fire incidence in regions heavily struck by the earthquake, fires occurred almost uniformly even other than Nagata-ward in Kobe City where large fires were concentrated. The incidence of fires following the earthquake seems to be in proportion to the degree of structural damage. This fact indicates that most of the post-earthquake fires were suppressed in their early stage by fire brigades as mentioned later. The concentrated occurrence of large fires happened around Nagata-ward not simply because of high incidence of fires, but because of the higher risks of fire spread, i.e. ratio of wooden structures, building coverage in the area, and width of streets, etc. in those regions. (See Figure 4 ³⁾ and Figure 5)

2.3 Fires by Size by Region

Table 3 and Figure 6 show numbers and percentages of post-earthquake structure fires from January 17 to January 19 by size and by region. The total number of fires by January 19 is 231, 132 of which are in Kobe, but other 99 are out of Kobe. However, twelve very large fires having burned area over 10,000 m² were concentrated around Nagata-ward in Kobe and, among 48 large fires having burned area over 1000 m² in the table, 47 fires occurred in Kobe City except the one in Nishinomiya City. In terms of average burned structures per fire as an index of average fire size by region, the cities other than Kobe have less than 2.0 (only Nishinomiya has 2.4, but still very small). Also, less damaged regions in Kobe like Tarumi-ward, Kita-ward, and Nishi-ward have less than 2.0. Only south east part of Kobe City had many large fires. This is also explained by the same reason as mentioned above.

3. THE FACTORS CONTRIBUTING TO FIRE TERMINATION

3.1 The Investigation on Large Fires in Kobe

In 6 days from January 26 to 31 in 1995, the Fire Research Institute organized an 11-member team including the author and investigated 21 large fire sites around Nagata-ward shown in Table 4. The purpose of this investigation was to obtain and maintain important information to clarify the areas burned by large fires and the factors of fire spread and its termination.

The results gained from the investigation on fire spread boundaries and factors of fire terminations were recorded on 1/2500-scaled maps. For example, Figure 7 demonstrates the fire site near Mizukasa-nishi Park. The paper space does not allow the explanation of the other fire sites, which are described in the Report⁵⁾ of the Fire Research Institute.

3.2 Proportion of Each Fire Stop Factor

Table 4 shows total extension distances along the fire spread boundaries of each large fire and the proportion of extension distances by fire stop factor which were estimated from the investigation.

At any fire spread boundary, fire brigades must have worked to extinguish fires finally. However, the fire stop factors treated here stand for factors that mainly functioned for fire termination. For instance, in the case that fire termination would have been difficult only by firefighting activity without factors as roads, open spaces, and fire-resistive buildings, the physical factors are considered as main factors. Also, in the case that fire fighting activity was done and essential or that it would not have been possible to put out fires without firefighting activity, suppression is chosen as a main factor, even if there are some other factors. Therefore, the proportion of factors was estimated after one factor was chosen as the main one, although several factors may have worked synthetically in some cases. Also, the effects of change of wind velocity and/or direction need to be considered to have our final results.

The tendency over the 21 fire sites is shown in Table 5: "Roads and railways" (40% of the total), "open spaces" (about 23%), and "fire-resistive buildings and walls" (also about 23%). These physical factors are up to 86% of the total. This result seems quite natural, since each fire site investigated was large enough to be beyond firefighting capability to control and needed natural fire stop factors on most part of fire spread boundaries to go off. On the other hand, "suppression" which was done mainly by firefighting activities of fire brigades and partly by activities of citizen volunteer teams, occupies about 14%. However, considering the definition of a main factor here and total extension distances on fire spread boundaries stopped by "suppression" in the 21 fire sites, 2,316m, the figure 14% is not small.

3.3 Comparison with Large Fires in The Past

The results described above were compared with the results of the 1923 Great Kanto Earthquake's proportion of fire stop factors. In the result⁶⁾ of the Kanto Earthquake whose total extension distances of fire spread boundaries of all large fires is 59.6 km, the firefighting activities as a fire stop factor score 15.1%, and the figure is close to 14% of that of the case in Kobe. In 1923, there was no category of fire-resistive buildings, maybe since there were not so many fire-resistive buildings and fire-proof wooden buildings. Open spaces, including roads (27%), occupied 72.5% of the total figure.

As one of very few recent large fires, the Sakata City Conflagration occurred in 1976. In this fire, the proportion of fire-resistive buildings in the total extension distances of fire spread boundaries was 16.7%.

From these facts, the proportion of "fire-resistive buildings and walls" (24%) observed in this investigation is not a small figure, that is, the role of fire-resistive buildings as a fire stop

factor cannot be neglected. Also, "roads and railroads" (40% of the total) plays an important role as a fire stop factor even though some are still narrow.

4. FIRE FIGHTING ACTIVITIES IN THE EARLY STAGE

4.1 Recognition of Fire Ignitions by The Fire Departments in The Early Stage

From just after the earthquake, all of the 118 emergency telephone lines became busy at the Headquarters of Kobe City Fire Department. Incident report calls to the Headquarters counted 441 by 7:00 a.m. and more than 6,000 by the end of January 17. However, most of the calls by 6:00 a.m. did not reply to the receivers. This kind of troubles, caused by malfunction of exchangers or transmittance system of Nippon Telegraph and Telephone Corporation (NTT), decreased as time passed. However, about 40% of the 6,872 calls received on the day did not transmit sounds.

However, even if they had received normal report calls, most of the calls could have been not emergency but to ask for information, as seen in Table 5⁷. Thus, it is doubtful whether incident reports on fires could be obtained effectively through the emergency telephone line, 119, in the case. It is very important to grasp disaster information actively and voluntarily as the experience of Nishinomiya City Fire Department.

The Headquarters of Nishinomiya City Fire Department recognized 16 fires on January 17. The professional fire brigades and volunteer fire corps found 11 out of the 16 by themselves, while working or supervising from some higher places. For 3 of the fires, citizen directly came to fire stations to report. Then, they had only one fire report call through 119 as the earliest notice. Actually, this has not been unexpected at all. The same thing happened in past earthquakes such as the 1993 Kushiro-oki Earthquake, and they will probably be observed again in future earthquakes as well.

The telephone plays a significant role in the modern society. The emergency call (to 119) system and the automatic dispatch control system, based on the calling system, naturally work in the general time. However, it should be considered that they may not be so reliable that they work always at the time of severe disasters like earthquakes. For example, there was considerable delay in recognizing occurrence of post-earthquake fires by the fire departments in the early stage after the Hanshin Earthquake as shown in Figure 8.

Therefore, it is absolutely needed to think of the system of collecting and communicating disaster information by alternative channels. Although it might not sound highly sophisticated, the author believes that "the system of collecting information by people" is necessary. In other words, we should consolidate the system of receiving direct reports from citizen, and also recognize the significance of collecting disaster information by fire personnel on their way to summon or patrolling fire engines in districts of jurisdiction. And, actually, the effectiveness of patrolling fire engines to collect information was already demonstrated by the experience of Los Angeles City Fire Department in the Northridge Earthquake.

4.2 The Performance of Fire Brigades Activities in the Early Stage

-- In Kobe City, Nishinomiya City, and Ashiya City --

Table 6 provides the data of post-earthquake structure fires in Kobe City, Nishinomiya City, and Ashiya City by 7:00 a.m. on January 17 and the initial conditions of fire brigades toward the fires in the initial stage.

In Kobe City, by 7:00 a.m., there were 63 simultaneous fires. Actually, the number of fires was more than that of fire engines, 40. Regarding three wards, Tarumi, Kita, and Nishi in Kobe, there was only one fire so that the fire stations there had much capacity left in the early stage to cope with fires in their jurisdictions, because firefighting operation of each fire station in the initial stage at an earthquake is usually concentrated upon districts within its own

jurisdiction. Therefore, the three wards had better be excluded when the firefighting capability in the early stage for Kobe City is considered. Then, they had only 28 fire engines, which were ready, against 62 simultaneous fires. In other words, as simply calculated, they could not cope with 34 fires at least. In Table 6, the number of large fires which burned more than 1,000m² is roughly equal to the number, the difference between the number of simultaneous fires and that of fire engines ready to go in each city or ward. This fact indicates that the extent of fire damage at an earthquake depends basically upon the balance of number of simultaneous fires and the fire fighting capability such as number of fire engines ready for use, if water supply like cisterns at least is secured.

The contents of firefighting activities in the cities of Nishinomiya and Ashiya are worth close studies. Nishinomiya City is one forth as large as Kobe City in population, and also its number of fires is about one forth as well by chance, as seen in the table. The Nishinomiya Fire Department possessed 14 fire engines to take care of 16 fires, and besides, they could have cooperation of the volunteer fire corps that possess more fire engines than the professional fire brigades have. They also had as many cisterns as Kobe City did. These factors effectively worked to hold fire damage the least, even though they could not use fire hydrants. The two fires "burning more than 1,000m²" were suppressed before they burned more than 2,000m².

The city development standard of Nishinomiya City demands at least one cistern per three of water supplies for firefighting. This is the reason the city has a lot of water reservoirs including private ones. In addition to that, they learned a lesson from a serious shortage of water in the summer of 1994, and made the "Manual of Firefighting Operation for Special Occasions with Shortage of Water". Before the earthquake, they already had practical training to use rivers and swimming pools, supposing a suspension of water supply, and this preparedness significantly helped to distinguish fires in the earthquake.

On the other hand, Ashiya City is populated about 87,000 and had simultaneous eight fires following the earthquake that is as high incidence as that of Nagata-ward in Kobe. Although fire hydrants were not available, the fire brigades put out fires so successfully that six fires burned only one building for each and that none burned more than 1,000m². They distinguished all the simultaneous fires in the early stage, which number was more than that of fire engines they had. Many fires, fortunately, started in fire-resistive structures. In addition, there are two other reasons pointed out: the cooperation of the volunteer fire corps who possess fire engines and the adequate use of two rivers running through the city.

4.3 The Dilemma How To Put The Priority on Firefighting or Rescue

The firefighting activities in the early stage, especially in Kobe City, were surely influenced by a dilemma how they should put the priority on firefighting or rescue of the buried alive in a number of collapsed buildings. However, the essence of this issue is, not the question of decision by fire personnel on site to distinguish fire or to rescue the buried, but exactly the fact itself that too many structures were destroyed as ever seen before and too many people were buried alive there. The basic purpose of the fire brigades' activity in the early stage at an earthquake is, obviously, firefighting to prevent conflagration, because fire service personnel are unable to respond all emergencies following a large earthquake.

Although a number of incidents to need rescue work happened at the same time in the Hanshin Earthquake, the author think that these happenings should be discussed as one of the crucial issues other than firefighting activities in the early stage. In other words, the fundamental countermeasures to be taken are to build earthquake-proof structures and also to reinforce existing old structures to be safe for preventing the same tragic situation. Moreover, a national emergency rescue system should be considered after the experiences of the USAR in the United States for incidents which need rescue work beyond the capability of a few local fire departments.

5. CONCLUDING REMARKS

As observed in Kobe City at the time of the Hanshin Earthquake, it might possibly happen again in future earthquakes that some fires are not suppressed in the early stage and grow up to conflagrations.

The point is how we prevent fire spread to minimize fire damage, but the solution should not be looked for only in firefighting capability, which has limitation. A fire that has grown to a conflagration can not be easily stopped only by firefighting activity. For example, the 1976 Sakata City Conflagration did not stop until it went to a big river, the Niida River, that is a natural fire stop boundary, even though 217 fire engines in total for there days were on duty. In order to prevent a conflagration, fire-proof city planning such as construction of fire stop boundaries along roads by widening and/or construction of fire-resistive structures, arrangement of location of parks, green zones, promenades, and open water or water reservoirs etc. is significantly necessary besides reinforcement of the firefighting capability.

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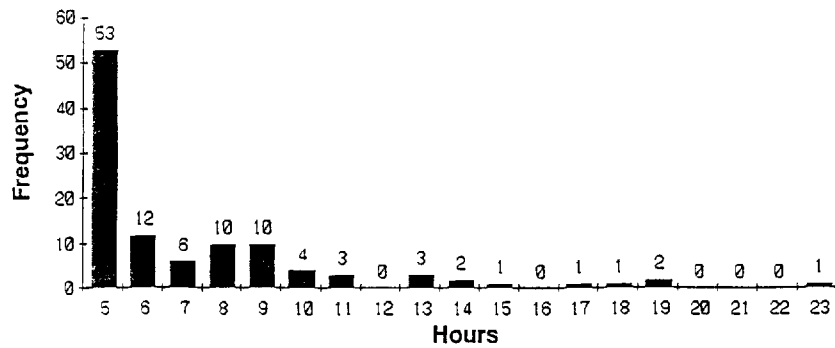


Figure 1. Frequency of fires by hours within January 17 in Kobe City for the 1995 Hanshin Earthquake.¹⁾

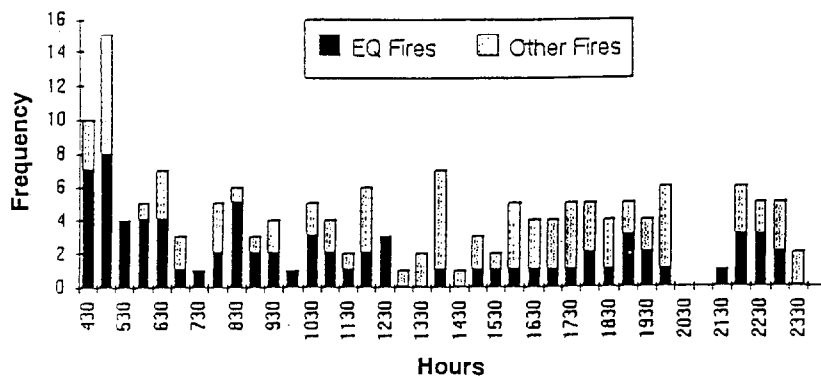


Figure 2. Frequency of fires by hours within January 17 in Los Angeles for the 1994 Northridge Earthquake.²⁾

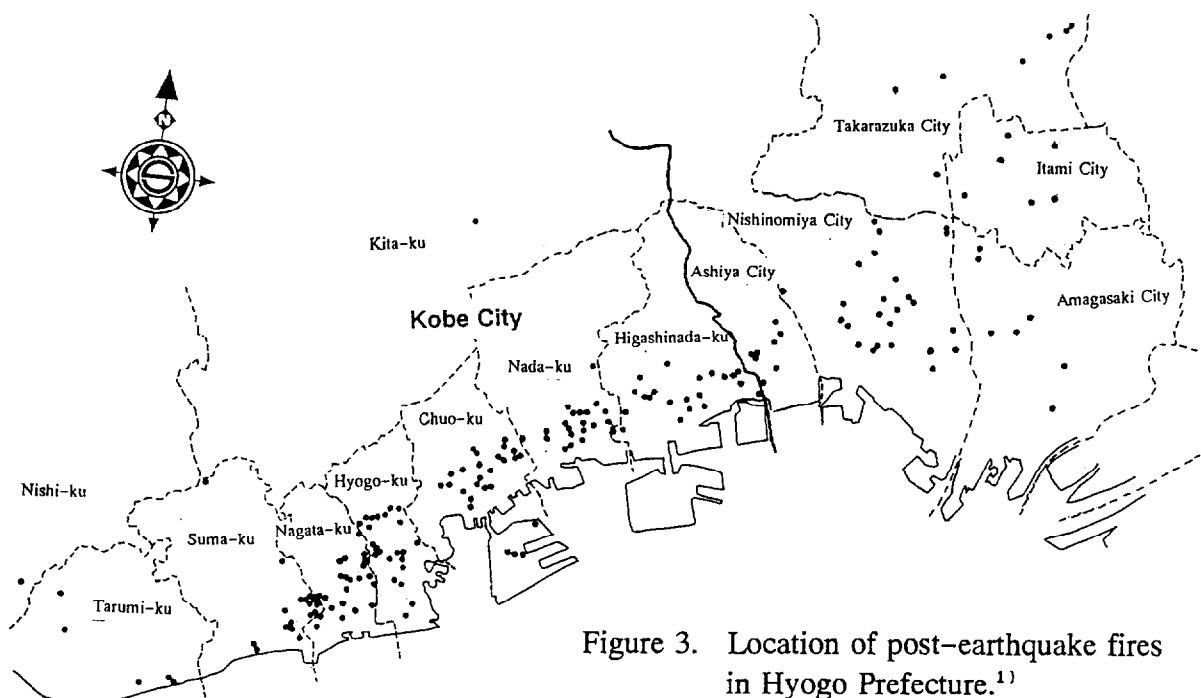


Figure 3. Location of post-earthquake fires in Hyogo Prefecture.¹⁾

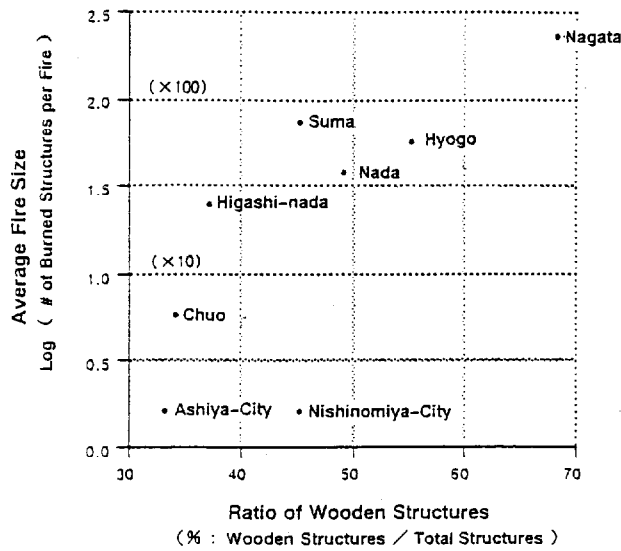


Figure 4. Relation between average fire size and ratio of wooden structures by region.³⁾

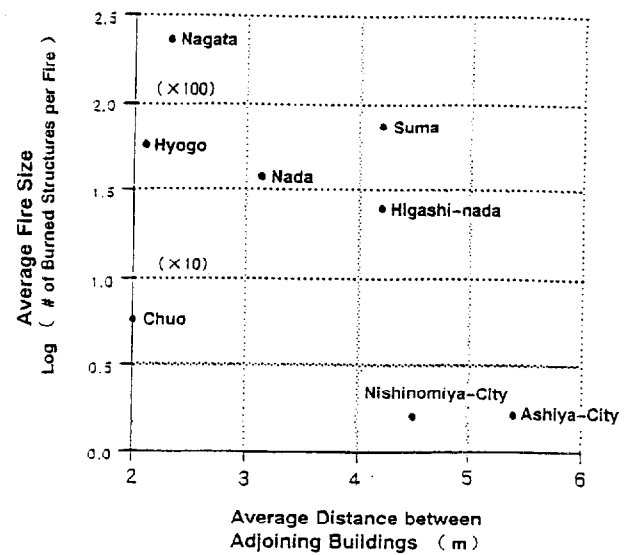


Figure 5. Relation between average fire size and average distance⁴⁾ between adjoining buildings by region.

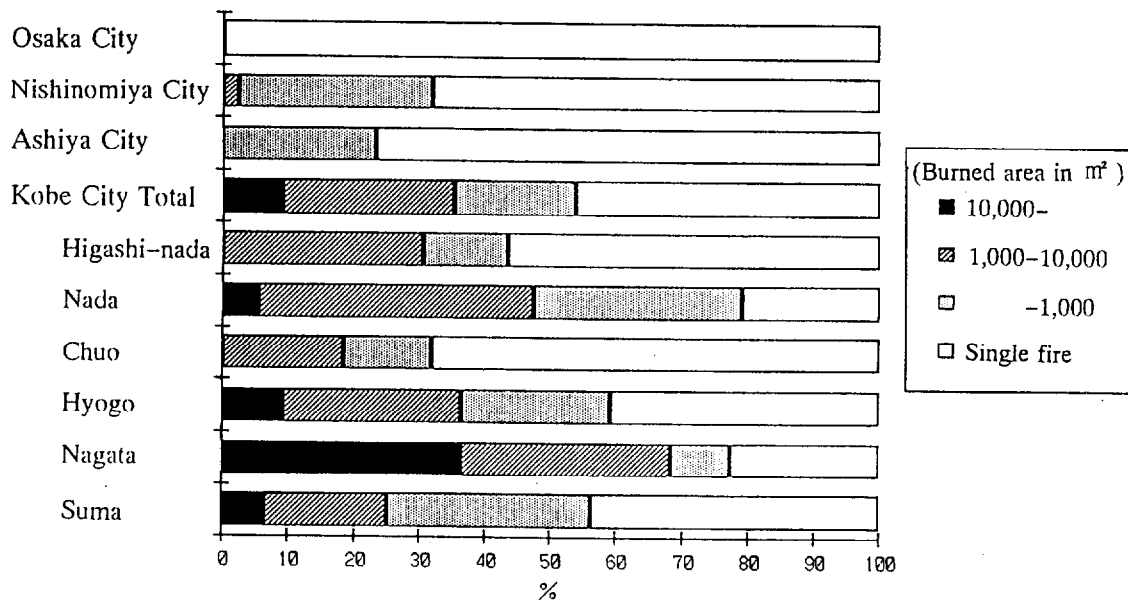


Figure 6. Proportions of post-earthquake structure fires by size by region.
(Fires for January 17th-19th)

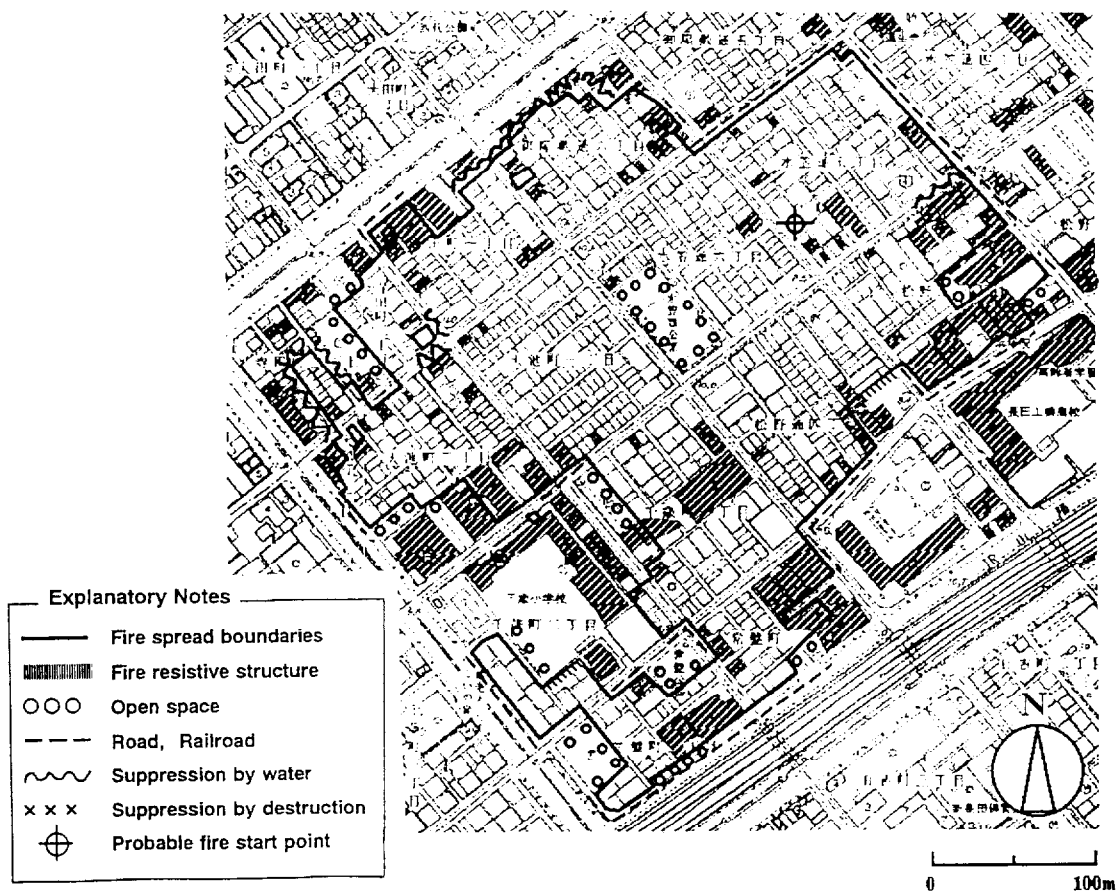


Figure 7. Fire spread boundaries and fire stop factors of the fire site near Mizukasa-nishi Park.⁵⁾

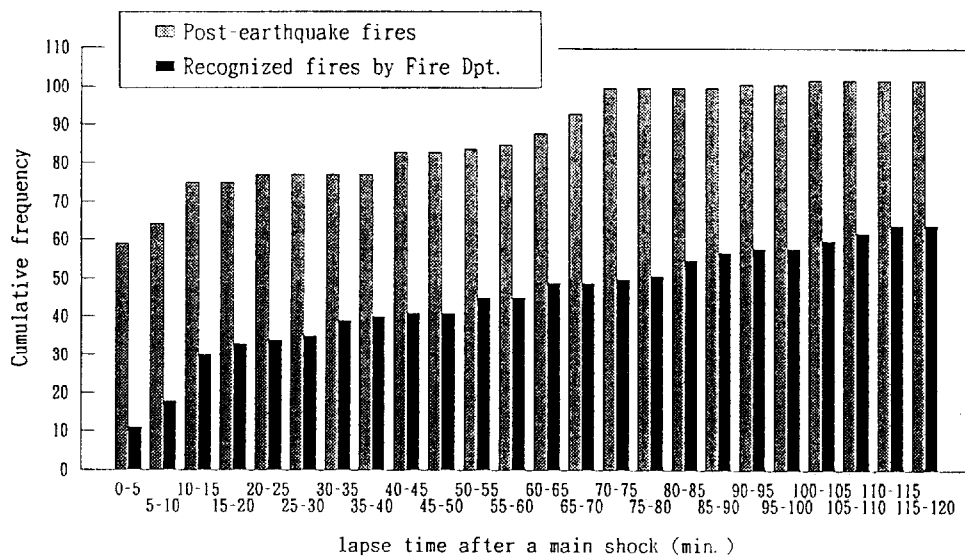


Figure 8. Cumulative frequency of post-earthquake fires and recognized ones by fire departments by lapse time after a main shock.

Table 1 Post-earthquake fires in time order for January 17-19 in Kobe City.

Kobe City by ward	1/17 ~6:00 ~7:00 ~8:00 ~9:00 ~24:00					1/17 Total	1/18 Total	1/19 Total	1/17-19 Total
Higashi-nada	10	1	2	1	3	17	2	4	23
Nada	13	0	1	1	2	17	2	0	19
Chuo	8	4	2	1	5	20	3	3	26
Hyogo	11	0	2	2	2	17	4	3	24
Nagata	13	1	0	0	3	17	1	4	22
Suma	4	4	0	4	1	13	2	1	16
Tarumi	0	0	0	0	6	6	0	0	6
Kita	0	0	0	0	1	1	0	0	1
Nishi	1	0	0	0	0	1	0	0	1
Kobe City Total	60	10	7	9	23	109	14	15	138

(The data as of November, 1995)

Table 2 Post-earthquake fires in time order for January 17-19 in cities other than Kobe.

Cities other than Kobe	1/17 ~6:00 ~7:00 ~8:00 ~9:00 ~24:00					1/17 Total	1/18 Total	1/19 Total	1/17-19 Total
Ashiya	4	4	1	0	0	9	2	2	13
Nishinomiya	11	11	1	1	10	34	4	3	41
Takaradzuka	2	0	0	0	2	4	-	-	4
Itami	2	2	2	1	0	7	-	-	7
Kawanishi	1	1	0	0	0	2	-	-	2
Amagasaki	3	2	1	0	2	8	-	-	8
Awajicho	1	1	0	0	0	2	-	-	2
Osaka	7	4	1	1	2	15	-	-	15
Toyonaka	3	1	0	1	0	5	-	-	5
Suita	1	1	0	0	0	2	-	-	2
Other Cities Total	37	26	5	4	16	88	6	5	99

Note: " - " means no post-earthquake fire reported.

(The data as of November, 1995)

Table 3 Numbers and percentages of post-earthquake structure fires by size by region.

(Note : Fires for January 17th - 19th. " m² " in this table is the unit of burned area.)

Wards for Kobe and other cities	# of fires over 10,000m ² (%)	# of fires 1,000~10,000m ² (%)	# of fires under 1,000m ² & beyond origin structure (%)	# of fires confined to origin structure (%)	Total number of fires by region	Total number of burned structures	Total burned area by region (m ²)	Average of burned structures per fire
Higashi-nada	0 (0.0)	7 (30.4)	3 (13.1)	13 (56.5)	23	377	32,811	16.4
Nada	1 (5.3)	8 (42.1)	6 (31.6)	4 (21.0)	19	562	65,234	29.6
Chuo	0 (0.0)	4 (18.2)	3 (13.6)	15 (68.2)	22	106	14,426	4.8
Hyogo	2 (9.1)	6 (27.3)	5 (22.7)	9 (40.9)	22	1,073	129,558	48.8
Nagata	8 (36.4)	7 (31.8)	2 (9.1)	5 (22.7)	22	3,156	302,732	143.5
Suma	1 (6.3)	3 (18.7)	5 (31.2)	7 (43.8)	16	1,027	90,079	64.2
Tarumi	0 (0.0)	0 (0.0)	0 (0.0)	6 (100.0)	6	6	59	1.0
Kita	0 (0.0)	0 (0.0)	1 (100)	0 (0.0)	1	3	54	1.5
Nishi	0 (0.0)	0 (0.0)	0 (0.0)	1 (100.0)	1	2	77	1.0
Kobe City Total	12 (9.0)	35 (26.1)	25 (18.7)	60 (46.3)	132	6,312	635,030	46.4
Nishinomiya City	0 (0.0)	1 (2.6)	12 (31.6)	25 (65.8)	38	90	7,784	2.4
Ashiya City	0 (0.0)	0 (0.0)	3 (23.1)	10 (76.9)	13	22	3,577	1.7
Amagasaki City	0 (0.0)	0 (0.0)	2 (25.0)	6 (75.0)	8	15	2,673	1.9
Akashi City	0 (0.0)	0 (0.0)	0 (0.0)	6 (100.0)	6	6	30	1.0
Itami City	0 (0.0)	0 (0.0)	0 (0.0)	7 (100.0)	7	7	57	1.0
Takaradzuka City	0 (0.0)	0 (0.0)	1 (33.3)	2 (66.7)	3	4	173	1.3
Awaji Cho	0 (0.0)	0 (0.0)	0 (0.0)	2 (100.0)	2	3	119	1.5
Osaka City	0 (0.0)	0 (0.0)	0 (0.0)	15 (100.0)	15	15	1,445	1.0
Toyonaka City	0 (0.0)	0 (0.0)	0 (0.0)	5 (100.0)	5	5	108	1.0
Suita City	0 (0.0)	0 (0.0)	0 (0.0)	2 (100.0)	2	2	3	1.0
Total	12 (5.2)	36 (15.5)	43 (18.5)	140 (60.9)	231	6,481	650,999	27.6

(The data as of November, 1995)

Table 4 Proportion by Fire Stop Factor along Fire Spread Boundaries for Major Large Fires.⁵⁾

Major Large Fire Sites	Fire Stop Factor		Road, Railroad		Open Space		Fire Resistive Bldg.		Suppression		Row Total	
	Length(m)	Ratio(%)	Length(m)	Ratio(%)	Length(m)	Ratio(%)	Length(m)	Ratio(%)	Length(m)	Ratio(%)	Length(m)	Ratio(%)
1) Ohta School North	110	31.4	145	41.4	30	8.6	65	18.6	350	100.0		
2) Ohta School South	165	38.8	75	17.6	55	12.9	130	30.6	425	100.0		
3) Ohta 4 Chome	55	48.9	25	22.2	33	28.9	0	0.0	113	100.0		
4) Near Yokozuna Bldg.	25	12.3	25	12.3	87	43.2	65	32.1	203	100.0		
5) Near Chitose Park	298	46.9	58	9.1	142	22.4	138	21.7	635	100.0		
6) Near Takahashi Hospital	812	64.6	298	23.7	124	9.9	23	1.8	1,258	100.0		
7) Near Nishidai Market	280	23.4	295	24.7	337	28.2	282	23.6	1,195	100.0		
8) Near Mizukasa Nishi Park	985	42.0	539	23.0	626	26.7	195	8.3	2,345	100.0		
9) Hiyoshi 2 Chome	143	58.8	82	34.0	17	7.2	0	0.0	243	100.0		
10) Shin-Nagata Sta. South	625	59.1	119	11.3	262	24.8	50	4.7	1,058	100.0		
11) Kobe Department South	262	24.3	170	15.7	365	33.8	283	26.2	1,080	100.0		
12) Hosoda 4 Chome	117	39.8	97	33.0	50	16.9	30	10.1	295	100.0		
13) Mihune-Dori 2·3·4 Chome	480	71.1	0	0.0	90	13.3	105	15.5	675	100.0		
14) Kawanishi 1 Chome	135	49.0	43	15.5	48	17.3	50	18.2	275	100.0		
15) Mikura-Dori 5·6 Chome	234	24.1	242	24.9	370	38.0	124	12.8	973	100.0		
16) Near Sugawara Market	528	40.0	442	33.5	350	26.5	0	0.0	1,320	100.0		
17) Higashi-Shiraike 7 Chome	197	61.7	37	11.7	0	0.0	85	26.6	320	100.0		
18) Egeyama South	642	23.4	942	34.3	686	25.0	472	17.2	2,745	100.0		
19) Nakamichi-Dori 6 Chome	178	58.7	40	13.2	53	17.4	32	10.7	303	100.0		
20) Uozaki-Kita 5·6 Chome	170	35.8	93	19.5	123	25.8	90	18.9	475	100.0		
21) Ogi Sta. South	235	49.2	38	7.9	107	22.5	97	20.4	478	100.0		
Summary of Above Fire Sites	6,676	39.9	3,805	22.7	3,955	23.6	2,316	13.8	16,752	100.0		

Table 5 The state of emergency call through 119 on January 17
at the Headquarters of Kobe Fire Department.⁷⁾

	Emergency call			Communication within Fire Department	Not emergency call			Total
	Fire	Ambulance	Others		Inquiry*	No response	Others	
5:46~ 6:00	0	0	2	0	10	24	0	36
6:00~ 7:00	11	17	45	7	74	243	8	405
7:00~ 8:00	19	19	96	15	43	234	20	446
5:46~24:00	237	297	981	258	2130	2762	207	6872

* To ask information on the earthquake.

Table 6 Performance of fire brigades activity in the early stage.¹⁾
— in Kobe City, Nishinomiya City, and Ashiya City

City or Ward	Number of burned structures	Structure fires until 7:00 am Jan.17			Number of fire engines ready at the earthquake	Damaged to fire hydrants	Number of cisterns
		Total number	Fires spread over 1000m ² burned area	Single fires (# of RC buildings)			
Nishinomiya City	90	16	2 (13%)	7 (3)	14 (+Volunteer's)	Damaged	927
Ashiya City	22	8	0 (0%)	6 (4)	5 (+Volunteer's)	Damaged	60
Kobe City Total	7,453	63	37 (59%)	17 (10)	40	mostly Damaged	1,303
Higashinada	379	9	5 (56%)	3 (3)	5	used up to 2 hours	38
Nada	626	13	7 (54%)	2 (2)	4	Damaged	100
Chuo	115	7	2 (29%)	4 (2)	5	Partially damaged	147
Hyogo	1,097	11	5 (45%)	3 (0)	5	Damaged	104
Nagata	4,073	14	11 (79%)	2 (1)	5	Damaged	93
Suma	1,149	8	5 (63%)	2 (1)	4	Damaged	129
Tarumi	9	0	0	0	4	Damaged	77
Kita	3	0	0	0	5	unknown	259
Nishi	2	1	0 (0%)	1 (1)	3	Damaged	356

(The data as of November,1995)

Discussion

Charles Scawthorn: Thank you for an excellent talk. Embers, fire brands, did they play any role in Kobe?

Ai Sekizawa: According to the testimony of the fire fighters of Kobe City, even if they believed that they could successfully stop the fire at some point, they saw the fire brands behind them, and another fire started.

Howard Baum: Is there any record of the natural winds that were present during the period of the fire?

Ai Sekizawa: Are you talking about the official record?

Howard Baum: Either that or any information that any other observers recorded. Basically, it would be very interesting to know what the wind patterns were in the affected area during the fire.

Ai Sekizawa: When it comes to the local wind speed and direction, I do not believe any official record has been prepared. We'll be able to come up with some information from testimony or some photographic evidence.

Donald Bathurst: I've got three questions. The fire department response seemed to be very good, but what impact did the attempt to rescue people have on their ability to respond. You showed the correlation between the number of fires and the number of engines available, but how many of those were diverted toward rescue? And was there an impact from the damage to the infrastructure in preventing the fire department from setting up in a timely manner.

Ai Sekizawa: I do not believe there is any specific data showing the impact correlation between rescue operation and extent of fires in other obstructions. In reality, as I mention in my paper, there is a huge dilemma faced by the people who are involved in these operations because they have to engage in rescue operations at the same time as fire fighting operations, and there is no definite division between those operations. They have to engage in whatever they have to do. I do not believe that there is any data which clearly shows the impact on the part of rescue operation.

Donald Bathurst: And the last point, there was significant relay operation with all the pumps. Were there any problem with fuel? Getting fuel for those long term operations?

Ai Sekizawa: Starting from the afternoon of the 11th, since we obtained assistance from neighboring towns and cities, we had pretty much established logistic conditions. We had help in that manner, including fuel, so we didn't experience any particular problems. The most difficult problem we faced was the severe congestion of traffic. Therefore, even if they wanted to rush to help us, they couldn't arrive at the affected area as soon as they wanted.